Lesson 263: PreAnesthetic Assessment of the Patient With Burn Injuries (Part 2)

PREANESTHETIC ASSESSMENT

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DATE REVIEWED: January 2007

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NEEDS STATEMENT

Burns destroy the skin, the largest organ in the body, which is responsible for thermal regulation, fluid and electrolyte homeostasis, and protection against infections. Burns are the only type of trauma that can be quantified as an exact percentage of damaged tissue. Burns also cause injuries to multiple organ systems that require the attention of a multidisciplinary team of specialists—including anesthesiologists—to ensure a good outcome. Patients with thermal injuries are frequently admitted to the emergency room and operating room; care of the patient with burns has been identified by the committee as essential information for the anesthesiologist.

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Part 1 of this 2-part lesson, which was published last month in Anesthesiology News (33(4):53-58), dealt with the initial resuscitation and assessment of the burned patient. Part 2 outlines the management of anesthesia and pain in the patient with burn injuries.

The anesthetic management of the patient with burn injuries begins with initial resuscitation and may continue through years of reconstructive surgery. Many different scenarios can arise. As mentioned in Part 1 of this lesson, the rule-of-nines method provides a good estimate of the total body surface area affected in an adult with a burn injury (Figure 1). In children, the Lund-Browder chart provides the most accurate estimate of the burned surface area because it takes into account changes brought about by growth (Figure 2).

Airway Management

Most acute problems of the airway are resolved before the burned patient arrives in the operating room for wound débridement. The trachea of a patient with major burns or an inhalation injury may already be intubated. If the patient’s trachea is not intubated and an abnormal airway has been identified preoperatively, an awake intubation is indicated only if the patient is able to tolerate the procedure. In the pediatric patient, tracheal intubation after an inhalation injury may be the best option. A patient with a normal airway and no risk for aspiration is managed by conventional I.V. induction of anesthesia followed by paralysis with a nondepolarizing muscle relaxant; an increased dose is usually warranted.1

Burns on the face and neck, with associated swelling and distortion, can make direct laryngoscopy difficult or impossible. Although intubation might have been possible a few days earlier, the continued development of scarring can increase the difficulty. Additionally, a loss of mandibular mobility may impair manipulation of the airway and make mask ventilation difficult. Under these conditions, fiber-optic intubation while spontaneous ventilation is maintained is a safe and reliable technique.2

Once the trachea has been intubated, securing the endotracheal tube may be a challenge in the patient with facial burns because the tape will not adhere to burned skin and cloth ties may contaminate the surgical field. In one useful technique, a septal tie is formed with 0.125-in umbilical tape. The tape is placed around the nasal septum and an 8F or a 10F red rubber catheter is passed through each nasir and retrieved from the pharynx by direct laryngoscopy and use of a McNeill forceps. A length of umbilical tape is tied to each of the catheters; as the catheters are pulled back through the nose, each end of the tape is pulled out of its respective nares to make a loop around the nasal septum. The uvula should be clearly visualized before the knot is secured. The knot in the nasal septal tie should be secure enough to prevent excessive movement of the

If you would like to write a CME lesson in Anesthesiology News, please send an e-mail to Elizabeth A.M. Frost, MD, at ElizFrost@ fiat.com.

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TARGET AUDIENCE

Anesthesiologists

LEARNING OBJECTIVES

At the end of this activity, the participant should be able to:

1. Discuss the epidemiology of severe burns.
2. Define the different degrees of burn injuries.
3. Identify causative factors related to burn injuries.
4. Explain the pathophysiology of burns.
5. Outline the initial management of a burn injury.
6. Discuss the anesthetic considerations in the management of the patient with burns.
7. Identify current and novel therapies.
8. Plan the means to establish the airway in a burned patient.
9. Review the pharmacologic implications.
10. Present an anesthetic plan.

CASE HISTORY

A 19-year-old man weighing 84 kg is scheduled for excision and débridement of his arms, neck, chest, and shoulders after a car explosion 5 weeks earlier in which 65% of his body was burned. He has undergone 4 previous surgeries—two for leg fractures and two for débridement and skin grafting—during his stay in the burn ICU. He has also had an episode of pulmonary edema; electrolyte abnormalities (including hypokalemia and hypophosphatemia), which have been corrected; and multiple infections.

CALL FOR WRITERS

With Burn Injuries (Part 2)
endotracheal tube but loose enough to prevent ischemic necrosis of underlying tissues.\(^3\)

It is important to realize that in cases of burns to the head and neck that require several sessions of débridement, a successful intubation a few days earlier may not guarantee later success. Scarring develops rapidly, and the airway must be completely assessed de novo before each session of débridement.

The ventilation of critically ill patients during the perioperative period is challenging at times. Patients with an inhalation injury or acute respiratory distress syndrome may require respiratory support that is beyond the capabilities of anesthesia machine ventilators. Special circumstances may necessitate moving an ICU ventilator into the operating room. This machine and its associated electrical and pneumatic connections are cumbersome and can interfere with patient access. Some of the larger burn centers have solved the problem by attaching an ICU ventilator to the anesthesia machine. This arrangement allows the same ventilation parameters that have proved effective in the critical care of the burn patient to be monitored without the inconvenience of added equipment.\(^3\)

**Monitors**

The choice of monitors for a burn patient—as for any critically ill patient—depends on the extent of injuries and physiologic state of the patient, and the planned surgery. The presence of burn ointment may make it impossible to place electrocardiography pads, and thus the use of needles may be indicated.

During perioperative monitoring, the clinician must stay attuned to rapid shifts in blood pressure and tissue perfusion associated with the massive blood loss that can accompany the excision of burn wounds. An arterial catheter provides information about pulmonary and metabolic status, in addition to hemodynamic function. An arterial catheter can also be used to observe waveform and respiratory variations in systolic blood pressure—useful for the titration of fluids administered for volume replacement. In addition, this catheter allows the rapid sampling of blood, which aids in the assessment of tissue perfusion and pulmonary function.\(^3\)

Patients with extensive burns, comorbidities, and complications of burns may benefit from the placement of a central venous catheter, which serves several functions. A determination of central venous pressure (CVP) is useful when fluids are titrated for volume replacement. Although it is a poor indicator of preload volume, the CVP can rapidly show the status of the filling pressure. If the pressure is low, then volume replacement will be an effective solution for hypotension. If the filling pressure is high, vasoactive infusion is more likely to be helpful. When an elevated CVP is seen with pulmonary capillary leakage from an inhalation injury or systemic inflammation, pulmonary edema is likely to ensue.

The information derived from a pulmonary catheter is usually not substantially helpful during the débridement of large wounds; however, in some cases the measurement of cardiac output and pulmonary artery occlusion pressure may be useful when inotropic support or high levels of positive end-expiratory pressure are required.\(^3\)

Urine output, a measure of both renal and global perfusion, is the most useful gauge of kidney function. An output of 0.5 to 1.0 mL/kg per hour is the recommended endpoint for fluid management in the burn patient. The presence of heme is a reliable indicator of a transfusion reaction or myoglobinuria; other signs and symptoms are often masked by general anesthesia or the hemodynamic changes associated with burn surgery.\(^2\)

**Vascular Access**

Establishing vascular access in the burn patient can be technically challenging, especially in a child. If peripheral veins are available and the CVP is not needed, a peripheral vein catheter may suffice. Such catheters should be secured with sutures to prevent them from dislodgment during full-body preparation and movement of the patient during surgery.

A central venous catheter that is sutured in place provides secure venous access—which is the preferable route for the administration of vasoactive drugs. A central venous catheter can often be helpful in the management of extensive burns that prevent adequate access to peripheral veins.\(^3\) The internal jugular and subclavian veins are used most commonly for central access, but femoral vessels provide an alternative route if burns are present around the neck. Femoral venous access is easier in most patients, especially those with poor perfusion, because the femoral vein is a larger, more central vessel. Alternatively, access by intraosseous cannulation can be considered for fluid resuscitation in children.\(^4\)

After insertion, the vascular catheters should be dated because most burn centers regularly schedule line changes to reduce the risk for sepsis. Central venous catheters should be changed over a wire after 3 days and moved to a new site after 7 days.\(^5\) Although the risk for infection is less with an arterial catheter than with a venous catheter, the risk for mechanical complication is much greater; thus, arterial lines are not changed as often as venous lines unless the site appears infected.\(^6\) The
It can be administered at a dose of 0.5 to 2.0 mg/kg.

The major drawback of ketamine is its tendency to produce dysphoric reactions—which can be decreased with the administration of benzodiazepines or thiopental and propofol. Some induction agents such as thiopental and propofol are more commonly used in patients returning for reconstructive procedures rather than in those in the acute injury phase; these agents are also chosen sometimes for patients with small burns and no airway or facial involvement when direct laryngoscopy is planned.

Volatile anesthetics can also be used. In pediatric patients without I.V. access, anesthesia is usually induced with sevoflurane if they do not have injuries that make airway manipulation difficult. An anesthetic technique that involves mask induction with halothane, nitrous oxide, and oxygen has been described as beneficial for induction in pediatric patients in the acute care setting; the use of halothane in the United States, however, has decreased significantly with the development and implementation of volatile agents that cause fewer side effects and have quicker recovery profiles (e.g., desflurane and sevoflurane). The technique may avoid the previously mentioned dysphoria that is associated with ketamine-based techniques.

Ketamine agents cause dose-dependent vasodilation and depress cardiac function and hypercapnic drive; in addition, the hypoxic ventilatory drive is attenuated at low concentrations. However, volatile agents used for the maintenance of anesthesia have predictable wash-in and washout kinetics and are a useful adjunct to other agents when titrated according to hemodynamic and ventilatory parameters. Of these agents, nitrous oxide has the least effect on cardiovascular and respiratory function and can be a useful component of a balanced anesthetic regimen if oxygen saturation permits (Table).

Regardless of the choice of induction or maintenance agent, the administration of supplemental opioids is essential to relieve the pain experienced by burn patients—even in the absence of movement or surgical procedures. Severely burned patients become tolerant to analgesics—the result of continuous and prolonged administration—and the agents should be titrated accordingly. The currently available opioids vary widely in potency, duration of action, and effects on the cardiopulmonary system. Most of the opioids have little effect on cardiovascular function, but because they are very potent respiratory depressants, the ventilatory status of patients should be closely monitored.

Dexmedetomidine, an α₂-adrenoceptor agonist with more selective sedative properties than those of clonidine, can be titrated by I.V. infusion. This was shown to be an effective method for sedating pediatric patients during dressing changes and minor debridement. Advantages of the technique include rapid reversibility and the ability of the patient to tolerate high doses and prolonged infusions of the drug without tachyphylaxis, so that dose requirements may decrease over time.

Regional anesthesia can be effective in burn patients, either alone or in combination with general anesthesia; however, it is limited to patients with small burns or those undergoing reconstructive procedures. For the patient undergoing surgery below the umbilicus, a lumbar epidural, spinal, or caudal anesthetic as a peroperative adjunct can be useful.

Extensive debridement with the potential for massive blood loss is a relative contraindication to epidural anesthesia because of the potential complication of hypotension. Epidural opioids can be administered, however, especially in the postoperative period, with sustained-release encapsulated morphine.

The greatest limiting factor in the use of regional techniques is the extent of the surgical field. Most patients with major burns have multiple injuries or extensive areas of harvested skin that are not easily anesthetized by regional blocks. Furthermore, regional techniques should not be performed through burned tissue because of the potential for infection.

### Selection of Anesthetic Agents

Many agents have been successfully used in burn patients for the induction and maintenance of anesthesia. I.V. drugs can be used for both induction and maintenance. The specific agent used will depend on the pulmonary and hemodynamic status of the patient, in addition to the difficulty involved in securing the airway. Ketamine, which may be used for induction and maintenance, offers some advantages. It can be administered at a dose of 0.5 to 2.0 mg/kg and generally preserves hemodynamic stability unless the patient is deprived of catecholamines or is compensating with maximal sympathetic activity. Furthermore, hypoxic and hypercapnic ventilatory responses are preserved and airway resistance is reduced with ketamine. Compared with other I.V. anesthetics, ketamine maintains airway reflexes and patency; however, some risk for aspiration still exists.

For patients who do not require ventilatory support and can breathe spontaneously, a margin of safety is added in case unintentional extubation occurs.

Some anesthesiologists use ketamine without intubation in burn patients undergoing surgery or a change of dressings. The technique has proved beneficial in patients with laryngeal burns because potential mechanical injury to a previously injured larynx is avoided. Ketamine is also effective in pediatric burn patients and uncooperative adults without adequate vascular access.

Because ketamine maintains spontaneous ventilation and induces dissociative anesthesia, it provides good conditions for the clinician to secure the airway via fiber-optic bronchoscopy. The addition of other anesthetics, such as volatile agents and opioids, should be avoided until the airway is secure because these agents depress respiratory drive and relax the pharyngeal muscles, thereby increasing the risk for apnea, airway obstruction, and laryngospasm.

Ketamine can be used alone or in combination with other agents to maintain anesthesia, either by infusion or intermittent bolus. The major drawback of ketamine is its tendency to produce dysphoric reactions—which can be decreased with the administration of benzodiazepines in adults and older children. Induction agents such as thiopental and propofol are more commonly used in patients returning for reconstructive procedures rather than in those in the acute injury phase; these agents are also chosen sometimes for patients with small burns and no airway or facial involvement when direct laryngoscopy is planned.
**Fluid Management**

Measurement of the traditional end points of blood pressure, heart rate, and urine output in conjunction with indicators of global perfusion status, such as base deficit and serum lactate concentration, is adequate for fluid management—in acute settings and in the operating room. Intraoperative fluid management involves the use of crystalloids, colloids, and blood products to maintain cardiac output, tissue perfusion, and oxygen delivery. Overtreatment increases the risk for pulmonary and tissue edema; the latter in turn increases the risk for failure of skin grafts.\(^1\)

**Blood Loss**

Blood loss can be massive during wound excision and grafting, and blood should be readily available before excision is initiated. Currently accepted guidelines from the American Society of Anesthesiologists (ASA) task force on blood products support transfusion almost always when the hemoglobin concentration falls below 6 g/100 mL but rarely when the concentration is 10 g/100 mL or higher.\(^2\)

However, a history of cardiac disease, advancing age, and other factors may heavily influence decisions pertaining to blood transfusions.

Several burn centers have recommended lowering the cutoff for an acceptable hemoglobin concentration in young and otherwise healthy patients to reduce exposure to blood products and conserve the supply. Few objective data are available on the optimal strategy for managing a cutoff for an acceptable hemoglobin concentration in young and otherwise healthy patients to reduce exposure to blood products and conserve the supply. Few objective data are available on the optimal strategy for managing a given patient’s anemic state.\(^1\)

The use of intraoperative tourniquets on burned extremities reduces overall blood loss and the rate of blood loss, thereby reducing the risk for hypovolemia during surgery. Whereas some centers apply compression dressings postoperatively to reduce blood loss after excision and grafting, others use topical epinephrine to achieve the same effect.\(^1\)

Table: Cardiovascular Effects of Inhalation Agents

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<th>Effect</th>
<th>Halothane</th>
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Adapted from Woodson LC et al.\(^3\)

**Postoperative Care**

When the patient is transferred to the postoperative care area, a detailed communication of the intraoperative course by the anesthesiologist must be made available to the staff. Impaired ventilation may be observed in the postoperative period, regardless of whether breathing is spontaneous or mechanically assisted. Results of blood gas analyses and the oxygen saturation can be used to guide ventilator management. The patient with an inhalation injury will benefit not only from rational ventilator management but also from a course of inhaled bronchodilators and mucolytics in combination with airway suctioning. Recently extubated patients require supplemental oxygen for at least the first few hours until the effects of general anesthesia dissipate. Airway support may be necessary initially.\(^3\)

Burn patients should recover in a warm environment. Postoperative hypothermia results in vasoconstriction, hypoperfusion, and metabolic acidosis. Radiant heaters, blood and fluid warmers, warm blankets, heated humidifiers for gas delivery, and a high room temperature are all warranted during the postoperative period to provide warmth to the recovering patient.\(^3\)

Even with strict attention by surgical personnel to intraoperative hemostasis, continued blood loss is still a common problem after the excision and grafting of large burn wounds—which are excised to bleeding tissue by necessity before skin grafts are applied. Massive intraoperative transfusion compounds the problem with dilution thrombocytopenia and coagulopathy. Meticulous postoperative care includes an ongoing assessment of blood loss and the transfusion of additional blood products as needed. The monitoring of urine output and CVP also helps to guide postoperative blood and fluid therapy.\(^7\)

**Thermodulation**

The maintenance of proper body temperature is critical for wound healing, coagulation, and recovery in patients with extensive thermal injuries. The skin contains sensory receptors for monitoring surface temperature, subcutaneous fat for insulation, and blood vessels that dilate or contract to dissipate or retain heat. The skin also prevents the evaporation of body fluids. Cutaneous burns compromise these functions, and larger burn injuries alter the central regulation of temperature control. The hypermetabolic state that occurs within days after thermal injury is associated with an elevated skin temperature that is perceived as cold and the elicitation of homeostatic reflexes to maintain body temperature. Burn patients respond to the perception of cold with the rapid development of shivering to generate heat and an increase in oxidative metabolism. In an individual with an already accelerated metabolic state, this response causes additional catabolic stress.\(^8\)

The perioperative period presents an additional risk for hyperthermia, which is poorly tolerated and associated with an increase in morbidity. Anesthetic agents impair thermoregulation, and large, exposed surface areas of the body along with open wounds allow evaporative heat loss. Aggressive efforts are necessary to minimize heat loss and prevent hypothermia during surgical procedures in burn patients. The room should be heated with radiant heaters if necessary, and the patient’s head and extremities covered if they are not in the surgical field. All I.V. fluids should be warmed; body temperature should be monitored closely and appropriate measures taken to avoid heat loss. An accurate and convenient way to monitor body temperature during surgery is to use a Foley catheter equipped with a thermistor probe to measure the bladder temperature.\(^9\)

**Pain Management**

One of the more pressing issues in caring for burned patients is adequate analgesia and sedation—not only postoperatively for intubated and mechanically ventilated patients, but also for patients in the initial phases of treatment and those requiring frequent changes of dressings. The pain of burns can cause psychological and functional difficulties and is difficult to predict from wound depth. The initial and ongoing painful stimulation of nerve endings affects peripheral and central mechanisms and promotes the development of chronic pain syndromes.\(^10\)

Pain management may begin with cooling of the burn and the use of inhalational anesthesia during surgery such as inhaled anesthetic agents. The I.V. administration of opioids is appropriate. After resuscitation, the patient may experience pain as severe as that which occurred prior to the injury. Opioids are administered as required with the occasional use of a local anesthetic administered into the wound. Severe pain may persist for several weeks. If severe pain persists, additional pain management is indicated. In some cases, long-term anesthetic agents may be administered in the burn unit to prevent severe pain. In rare instances, multitudes of solutions have been used in treatment but with no demonstrated benefit. The use of local anesthetic medications directly into the burn wound has been suggested as a benefit, but the data are not well supported. Pulsed electromagnetic field therapy has been suggested but is not well supported. Heat can be beneficial if it is within a range that is safe for the skin. Exercise, massage, and hydrotherapy are helpful in many cases. The timing of such therapies should be considered carefully to avoid exacerbating pain.\(^10\)
The pain service should be accessible and provide adequate comfort—especially in patients who may be consulted and included as part of the team.

Burn patients often receive care from emergency response teams, nurses, and doctors before reaching a tertiary care setting. Because guidance for these healthcare providers is often lacking, a 9-step program has been devised for the initial management of the burn patient in the prehospital environment. The program is based on available evidence and consensus from specialists of all disciplines.1-13

The optimal care of patients, especially children, requires a multidisciplinary approach, including psychological and pharmacologic interventions, to relieve pain and reduce the patient’s emotional and mental stress.14 The pain service should be consulted and included as part of the team.

Basically, simple things should be performed well. The debridement of burned tissue and harvesting of skin grafts are painful procedures that necessitate ample analgesia to ensure adequate comfort—especially in patients who may be opioid-tolerant.1 In a study of 60 adults whose burns covered more than 20% of their body surface area, patient-controlled analgesia with fentanyl 30 mcg (5-minute lockout interval) following an initial bolus of fentanyl 1 mcg/kg was shown to be safe and feasible during dressing changes.15 Other studies have shown that the continuous I.V. administration of morphine with elastomeric infusers at a fixed dosage provides analgesia safely and effectively.10 Patient-controlled intranasal fentanyl may be substituted for oral morphine. Both techniques were found to be of equal efficacy and safety in a study of 26 patients.17

Management of the Case Presented

A physical examination and review of systems revealed limited movement of the patient’s neck. Preoperative laboratory testing showed a hemoglobin level of 9.8 g/dL and a hematocrit of 29.8%. Two peripheral veins were cannulated, and routine ASA monitors were placed. After induction with propofol, fentanyl, rocuronium, and lidocaine, a size 3 Macintosh laryngoscope blade was used, but visualization was poor. A second attempt was made at visualization with a Miller size 3 blade, and an Eschman catheter was placed through the vocal cords. An 8.0-cm endotracheal tube was placed over the catheter. Anesthesia was continued with desflurane, oxygen, air, and additional fentanyl. The 2.600 mL of lost blood was replaced with 4 units of packed red blood cells, 500 mL of hetastarch, and 4 L of Ringer’s lactate solution. The patient was transferred to the burn ICU and intubated with stable vital signs. Postoperatively, the hemoglobin level was 9.3 g/dL and the hematocrit was 27.4%. The patient was scheduled to return to the operating room the following week for further débridement.

Conclusion

The perioperative management of the burn patient poses numerous cognitive and technical challenges for the anesthesiologist. Anatomic distortions can make airway management and vascular access difficult. Pathophysiologic changes in cardiovascular function and metabolism can alter the response to anesthetic drugs. The safe and effective anesthetic management of burn patients requires a thorough understanding of the spectrum of changes from the initial resuscitation through the period of wound healing. Care of the burn patient requires a multidisciplinary approach with effective communication between members of the team. The anesthetic plan should remain consistent with ICU management and the overall goals of the patient’s treatment.

References


Post-test

1. Which of the following is true regarding the use of succinylcholine in burn patients?
   a. Sensitivity to succinylcholine is decreased in burn patients.
   b. Burn patients exhibit an exaggerated hyperkalemic response to succinylcholine.
   c. Most clinicians use succinylcholine frequently for surgery in burn patients.
   d. The altered pharmacologic response to succinylcholine is usually minimal, and thus the agent is safe to use.

2. The following are all advantages of ketamine for the induction and maintenance of anesthesia during surgery in burn patients, except:
   a. preservation of hemodynamic stability, even in patients deprived of catecholamines
   b. preservation of hypoxic and hypercapnic ventilatory responses
   c. reduction of airway resistance
   d. preservation of airway reflexes and patency

3. The management of pain in the burn patient:
   a. can best be achieved by an increase in the opioid dose
   b. is more successful with multimodal techniques
   c. should be left to the pain management team
   d. should be delayed until the airway is secured

4. The consequences of undertreating pain due to a burn include the following:
   a. psychosis
   b. chronic pain syndromes
   c. depression
   d. all of the above

5. Which of the following is a true statement regarding burn injuries?
   a. The application of sponges soaked in epinephrine 1:10,000 has little effect on levels of circulating catecholamines.
   b. The cardiovascular response to catecholamines is lowered.
   c. The affinity of β-adrenergic receptors is increased.
   d. The production of second messengers is unchanged.

6. Dexmedetomidine:
   a. should not be given for prolonged periods
   b. causes early tachycardias
   c. contains sedative properties than those of clonidine
   d. is rapidly reversed

7. The blood loss associated with burn surgery is likely caused by:
   a. deep surgical excisions
   b. dilutional thrombocytopenia
   c. hypothermia
   d. all of the above

8. Fibrin dressings:
   a. contain high concentrations of fibrinogen and thrombin
   b. are relatively inexpensive
   c. may be used for deep wounds
   d. have a long shelf life

9. Hypothermia in the burn patient:
   a. is associated with higher mortality rates
   b. helps to lower the perception of pain
   c. improves the neurologic outcome
   d. is rarely a problem because of the patient’s hypermetabolic state

10. A limitation of epidural analgesia in patients undergoing surgery for burns is:
   a. failure to provide adequate postoperative pain relief
   b. an extensive burned area requiring grafting
   c. nonexistent; analgesia for all burn surgery below the clavicle can be managed by this technique
   d. the potential for infection